

Capturing Science Teachers' Epistemological Beliefs: The Development of the Teacher Beliefs Interview

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Abstract

For the last five years we have used a semi-structured interview, which we refer to as the Teacher Beliefs Interview, to explore the beliefs of beginning secondary science teachers who were involved in different induction programs. Our initial questions focused on teacher epistemologies and probed the beliefs of beginning and experienced teachers, while our process of interviewing utilized methods common in qualitative research. In reviewing and refining our interview process, we developed maps that allowed us to describe and define various beliefs held by pre-service, beginning/induction, and experienced science teachers. Our current Teacher Beliefs Interview is based upon the analysis of semi-structured interviews with over 100 pre-service, induction, and in-service science teachers. Ultimately, these maps have allowed us to track the development of science teachers, while providing feedback regarding the effectiveness of our pre-service and induction programs.

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Introduction

Over the years, educational researchers have explored a variety of constructs pertaining to teachers in order to help improve the structure and impact of teacher education programs. Areas of study include teacher practices, teacher attitudes, and teacher knowledge. Another area of focus--and the subject of the present article--is that of teacher beliefs. Early researchers considered beliefs to be the information a teacher held about a person, a group of people, a behavior or an event (Fishbein & Ajzen, 1975). Within the last 15 years, understanding and describing teacher beliefs has become a priority for educational researchers. These personal constructs can provide an understanding of a teacher's practice: they can guide instructional decisions, influence classroom management, and serve as a lens of understanding for classroom events (e.g. Jones & Carter, 2007; Pajares, 1992; Richardson, 1996). A substantial body of research has been generated in this domain (see Jones & Carter, 2007; Richardson, 1996).

In science education, research on beliefs has been linked to the use of inquiry, national reforms, or constructivist practice in the classroom (e.g., Hashweh, 1996; Tsai, 2002; Wallace & Kang, 2004; Yerrick, Parke, & Nugent, 1997). Wallace and Kang's (2004) study of six experienced teachers, for example, revealed how the beliefs teachers held influenced the degree of implementation of inquiry and laboratories in their science

classrooms. Hashweh's (1996) study of 35 science teachers found that constructivist beliefs corresponded with constructivist behaviors. Yerrick, Parke, and Nugent (1997) concluded that science teachers needed to explore and examine their underlying beliefs about teaching and learning inquiry in order to assimilate an accurate representation of this reform into their conceptual framework. For science educators, understanding the beliefs of teachers is essential and important if teacher education programs are going to support the on-going development of science teachers (Keys & Bryan, 2001).

In our exploration of teacher beliefs, we have tried to understand how beliefs are modified as a teacher progresses from his or her pre-service program through the later years in a teaching career. Our initial interest in this area was guided by our observation that many of our pre-service teachers held beliefs conducive to reform-based practices, yet during their first years in the classroom few reform-based practices or beliefs were evident. This was compounded by our experience in professional development programs for experienced teachers, which revealed that these teachers held and formed reform-based beliefs as they learned new methods of instruction and assessment. We hoped that by understanding the change in beliefs of a teacher, we could design programs for teachers that would support their development towards constructivist or reform-based ideologies. In this process, we began documenting the beliefs of teachers and developed the Teacher Beliefs Interview (TBI), which helped us understand how teachers were impacted by their teacher education experiences. This paper reports the process of developing the TBI and our current use of the TBI with beginning secondary science teachers, along with the results of our initial studies.

Related Literature

Descriptions of Beliefs in Educational Research

Educational researchers have described beliefs in different ways. Some researchers lump beliefs and attitudes together and give little attention to the unique attributes of each (e.g., Garmon, 2004). Other researchers interchange terms such as theories and philosophies with beliefs, acknowledging that these are personal constructions (e.g., Simmons et al., 1999). Still other researchers equate beliefs and knowledge, as both guide actions and inform an individual's decision making process (e.g., Kagan, 1990). In some instances, the assumptions underlying the varied terminology are detailed, and in other instances there is little discussion. Given the disparity, those who study beliefs need to clearly articulate the nature of the beliefs that are being examined.

Those who have written about beliefs acknowledge their unique composition and cognitive affiliation (e.g., Fang, 1996; Fishbein & Ajzen, 1975; Jones & Carter, 2007; Nespor, 1987; Pajares, 1992; Richardson, 1996; Rokeach, 1986). For these researchers, beliefs are clearly personal constructions, entities that belong to an individual. Yet additional descriptions reveal varied notions of beliefs. For instance, Fishbein and Ajzen (1975) suggest that

“a belief links an object to some attribute...the object of a belief may be a person, a group of people, an institution, a behavior, a policy, an event, etc. and the

associated attribute may be an object, trait property, quality, characteristic, outcome or event (p. 12).”

Nespor (1987), on the other hand, describes beliefs as episodic, highly personalized, and containing affective and evaluative components. Descriptions similar to those offered by Nespor (1987), which are characterizations about beliefs, are more widely acknowledged by educational researchers.

The discrete and multidimensional nature of beliefs is less problematic to those who study beliefs. Schommer (1993), like other researchers, has found that individuals can hold beliefs that are independent of one another and have a varied impact on actions or cognitive processes. This means that individuals can hold beliefs that are in conflict with one another, that have different representations, and that are both generalizable and context specific. This variability is often associated with the core and peripheral nature of beliefs (Brownlee, Boulton-Lewis, & Purdie, 2002; Rokeach, 1986), and affects one’s cognitive schema in different ways. Core beliefs are often more connected within a system and are more coherent with one another, while peripheral beliefs are not as extensively connected to other beliefs in the system and may be in conflict with one another. Moreover, beliefs that are more central and more connected can be more resistant to change (Kagan, 1992). Adding to this, the position of a belief and its construction may result in the belief acting as a filter. As a result, more compatible experiences or information may be processed within a belief set, while incompatible experiences may be held to the periphery, filtered, or rejected (Nespor, 1987).

Capturing Teacher Beliefs

Beliefs are critical when it comes to understanding a teacher’s practice. Ernest (1989), for example, found that two mathematics teachers with similar knowledge taught in different ways. He suggested from his study that an understanding of beliefs was more useful in predicting teachers’ classroom decisions. Fang (1996), in a review of research on beliefs and practices, synthesized the research on the relationship between beliefs and practice and suggested that beliefs tend to affect behaviors. He also noted that factors outside of the classroom and teacher can also impact practice. Fang’s findings are consistent with other educational researchers, who generally agree that beliefs are connected to actions in the classroom (e.g., Guskey, 1986; Hashweh, 1996; Kang & Wallace, 2004). However, these and other authors indicate that pressing issues pertaining to beliefs and practice still exist, such as the nature of the interaction between beliefs and practices. Some researchers consider beliefs and practices to be interactive, while others conclude that beliefs must change before practices can change. In either case, it is important to understand the teaching beliefs of teachers, in light of the compelling evidence that beliefs influence practice.

Researchers often explore the beliefs teachers hold at different times in their careers. Richardson (1996), in her review article, concluded that professional development opportunities for experienced teachers were likely to have the greatest impact on beliefs. Such opportunities can influence experienced teachers to expand and modify their existing beliefs. Richardson also concluded that pre-service experiences were ultimately too short in duration to have any lasting impact on beliefs. Luft (2001), in

a study of experienced and beginning teachers, found that beginning teachers were more likely to change their beliefs when learning about inquiry but less likely to change their practices, while experienced teachers were less likely to change their beliefs and more likely to change their practices. The degree that beliefs of new teachers were able to change was attributed to the formidable nature of the beliefs. The experienced teachers, on the other hand, had beliefs about teaching that were established and consistent with the goals of the professional development program, which in turn influenced their decision to even participate in the program. Clearly, the beliefs of teachers are subject to varying degrees of change throughout one's career. These changes are indicative of the types of beliefs examined and the central or peripheral nature of the beliefs.

More recently, educational researchers have focused on epistemological beliefs. These beliefs concern teachers' views about nature and the acquisition of knowledge (e.g., Bendixen, Dunkle, & Schraw, 1994; Hofer & Pintrich, 1997). Such beliefs are intertwined with teachers' beliefs about learning, understanding, or student knowledge; as how a teacher conceptualizes knowledge impacts their teaching beliefs (Brownlee, Boulton-Lewis, & Purdie, 2002). In order to capture and describe these types of beliefs, the research process must allow teachers to describe and elaborate on their beliefs about knowledge and teaching. Interviews, ranking tasks, and constructed response formats have been used to capture teachers' epistemological beliefs; these methods allow teachers to thoroughly discuss the conceptualization of their beliefs (Ambrose, Clement, Philipp, & Chauvat, 2004; Munby, 1982).

Methods

Background

In order to understand, or elicit the beliefs of teachers, it is important to make beliefs "visible." Fang (1996) and Munby (1982) noted the shortcomings of written self-report responses that may reflect what should be done rather than what is actually done in practice. Pajares (1992) and Richardson (1996) stated that multiple forms of data were needed in order to understand teacher beliefs, although collecting this type of data can be difficult for even the most seasoned researcher. The semi-structured interview poses an alternative to written responses and multiple data sources. This format allows the researcher to access the thinking of a teacher and to determine aspects of the teacher's thinking that cannot be captured through observation or other modes of data collection (Patton, 1980).

In our research, the qualitative methodology of interviewing was used to develop the TBI. Semi-structured interview questions were used to elicit the beliefs of each teacher, allowing the interviewer to probe the thoughts of the teacher in order to understand his or her beliefs. Berg (1998) and Patton (1990) guided the development of our identified interview questions. Once the interviews were collected, they were inductively analyzed in order to understand how certain perspectives were manifested within the teacher. Patton (1990) refers to this as an orientational methodology.

Process

After reviewing the research on beliefs and consulting with experts who study teacher beliefs, we developed eight questions for the TBI. The initial questions were drawn from Richardson and Simmons (1994) as well as our own protocol (Roehrig, 2002). Using the initial questions, four researchers then conducted interviews with ten beginning secondary science teachers. The responses were collected and used to revise the interview process. We aimed to produce standardized, open-ended questions that were clearly stated to the teachers and that explored their beliefs (Patton, 1990). Our initial revisions included shortening the questions, revising the wording in order to capture the beliefs of teachers, and removing one question from our interview sequence. Once again, we reviewed the questions and answers of teachers to determine if we were capturing beliefs. Our review specifically sought to determine if the questions elicited teacher responses that were highly personalized, often constructed in episodic ways, and contained affective and evaluative components (see Nespor, 1987; Pajares, 1992). Moreover, we examined the questions to determine the presence of an object and an attribute, and an orientation towards knowledge (see Bendixen, Dunkle, & Schraw, 1994; Fishbein & Ajzen, 1975). Through an iterative process of revision and reflection, eight questions were developed.

During the next phase of the development of the TBI, three researchers inductively analyzed 75 transcribed interviews of beginning and experienced secondary science teachers in one state. Through this process the major concepts, themes, or categories present within each question were identified. Categories that emerged from the transcripts of the interviews resulted from the constant comparative method of data analysis (Glaser & Strauss, 1967). Each question and its corresponding categories were then placed in a clustered summary display (Miles & Huberman, 1994), which later gave rise to a graphical representation of the question.

The emergent categories for the questions were traditional, instructive, transitional, responsive and reform-based. Traditional and instructive responses represent teacher-centered beliefs, while responsive and reform-based responses represent student-centered beliefs. Transitional responses reflect a view of students that focuses on primarily behaviorist and affective attributes of students, not always the cognitive involvement. A further elaboration of the epistemological underpinning resulted in three areas of classification, which are similar to those found in Ernest (1989). Specifically, traditional responses reveal science as based on facts, rules and methods that are transferable; transitional responses represent science as a body of certain knowledge; while reform-based responses support science as a dynamic field that is subject to revision. Table 1 summarizes these categories and the epistemological underpinnings.

The final phase of development of the TBI entailed conducting interviews with pre-service, induction, and experienced science teachers in three different states. Over 40 interviews were conducted, and in some instances multiple interviews were conducted with participants during a two-year period. The interviews were analyzed by two different researchers, with the answers compared to the current TBI. After the coding of these interviews, three researchers met to revise the TBI to better represent the beliefs of the expanded group of teachers. This final meeting resulted in the deletion of one question and the formal connection of the questions to different epistemological domains

in science teaching. While these categories are not comprehensive, they are broad enough to depict the epistemological beliefs of science teachers. The final TBI questions are presented below, while the questions with selected responses can be found at the end of this paper.

1. How do you maximize student learning in your classroom? (learning)
2. How do you describe your role as a teacher? (knowledge)
3. How do you know when your students understand? (learning)
4. In the school setting, how do you decide what to teach and what not to teach? (knowledge)
5. How do you decide when to move on to a new topic in your classroom? (knowledge)
6. How do your students learn science best? (learning)
7. How do you know when learning is occurring in your classroom? (learning)

Reliability & Validity

In order to determine the generalizability of the TBI to other discipline teachers, we used the TBI with pre-service mathematics teachers. At first, one might think that teachers would provide similar answers across subjects. However, this was not the case. In their answers, teachers clearly drew upon their content knowledge and their understanding of the nature of knowledge construction in mathematics. The answers provided by mathematics teachers differed from those of the science teachers, thus supporting the reliability of the questions. In addition to questioning other groups of teachers, we reviewed the responses of the teachers and our own questioning process. The language and explanations of the interviewed teachers indicated that we had created a non-threatening atmosphere in which genuine responses were possible. Our own verbal cues, along with the responses from the teachers, give us confidence in the reliability of the responses (Fowler, 1993). Finally, the Cronbach alpha coefficient for the internal consistencies survey was calculated at 0.70.

Determining the validity of this process entailed multiple reviews of the interviews, as well as comparisons with data from other interviews that were collected in the course of the study. In each instance, we tried to identify alternative constructions and to determine if they were truly different, or if they aligned with our categorizations. Throughout our process of reviewing interviews and examining the responses, we found that our depictions held up, thus the validity of our process was supported (Patton, 1990).

Limitations

Before discussing the results of the TBI and our process of documenting different groups of teachers, we need to acknowledge the limitations. First, the very nature of identifying beliefs is difficult. In trying to capture the beliefs of teachers, we may have inadvertently captured behavioral intentions, which represent a person's intention to perform various behaviors (Fishbein & Ajzen, 1975). However, we were conscious of this problem and sought to capture beliefs by having teachers describe the epistemological side of the event. Second, even though we tried to adhere to methods that address issues of reliability and validity, these are areas of concern with just one method

of data collection. In an effort to address this issue we involved multiple researchers, examined the data different times, expanded our data collection to multiple interviews and different geographic areas, and worked with our subjects to establish rapport in order to enhance our access to their thinking (Patton, 1990). Although there are limitations associated with this process, we have confidence that our generated representations reveal the beliefs of science teachers.

Using the TBI

We are currently using the TBI to track changes in the beliefs of beginning secondary science teachers in different induction programs, and pre-service teachers who are participating in a teacher preparation program that begins during their freshman year. Both of these studies are tracking teachers over a period of time and as a result the teachers are participating in belief interviews over several years.

In preparing to talk to a teacher about his/her beliefs, we often begin our scheduled session by asking the teacher to talk about his or her current experiences as a new teacher or as a student in a teacher preparation program. In our experience, this allows the teacher to talk about his or her experiences and develops a comfort level with the interviewer that allows for a deeper discussion of thinking later in the interview process. This beginning part of the interview usually lasts from 10 to 30 minutes and can result in teachers discussing student accomplishments, well-developed lessons, or experiences that are conducive to their growth as a teacher. Following this section of the interview, we begin the interview about beliefs. As we interview the teacher, we ask for examples and rich details that highlight the epistemological side of the question. Additionally, we do not have the TBI maps with us, as this would guide our questioning towards areas in the maps. When we complete the interview, we always ask the teacher if there are additional comments he or she would like to make about being a science teacher. This often results in an additional 5 to 15 minutes of discussion. The entire beliefs interview process usually lasts from 20 to 30 minutes, and all of the interviews are digitally audio-taped. The duration of the interview depends on the comfort of the teacher with the interviewer. It should also be noted that most teachers are not interviewed by the same person, as this helps to ensure we have the best representation of the teacher's thinking over time.

Once the interviews are conducted, they are transcribed and coded or they are coded directly from the digital tape recording. Each interview is scored independently by two researchers. During the coding process, notes are made by each researcher on a separate piece of paper that summarizes the beliefs of the teacher. The last coder is responsible for looking at the level of agreement between both coders. If there are areas which are not in agreement, either both researchers can visit the question(s) that do not agree or a third researcher can listen to data, examine the prior codings, and make a decision. Once the codes are determined, the responses are merged to depict a beliefs profile that represents a teacher's beliefs over time (see Luft, 2001 for a more comprehensive report of the process). Table 2 is an example beliefs profile.

The resulting beginning and ending categories are then compared to each other to produce a summary of the teacher's beliefs. This is done to determine the degree of change or to establish a predominant teaching philosophy of the teacher. When we found

variations between pre- and post-interviews, we noted beginning teachers' beliefs about teaching as shifting, alternating, or not changing. A shift in beliefs about teaching results when three or more of the answers in the post-interview move one category or more to a student-centered or teacher-centered ideology, and/or in expanded answers that reveal new understandings. This type of change depicts beliefs that are becoming similar in orientation. An alternation of beliefs about teaching occurs when three or more of the answers move to teacher-centered or student-centered categories, instead of all responses moving in one direction, and/or when responses indicate new or refined ways of explaining teaching that emphasize teacher or student-centered approaches. Alternating beliefs are not stable and have the potential to move again. It should be added that the modification or change in at least three answers tends to be the threshold indicating important shifts in beliefs. That is, teachers who changed at least three categories were in the midst of constructing new or modifying existing belief systems. No change in beliefs occurs when only one or two participant responses shift categories, and/or when no expanded discussion occurs. Generally, beliefs with this degree of change are relatively stable.

An Example

An Interview with a Teacher

The post-interview of Sandy (pseudonym), a first-year secondary science teacher, was conducted in the office of a researcher at the university. She arrived early and was excited to discuss the completion of her first year as a middle school science teacher. Her school consisted primarily of Hispanic students; most of the children learned English as their second language and participated in a district program that provided meals for free or at a reduced cost. Sandy wanted to teach in this setting, though it was not always an easy place to work. Once Sandy was comfortable and the basics had been covered, the beliefs portion of the interview began.

In response to the first question about maximizing student learning in the classroom, Sandy paused for a bit, then said, "By using lots of different types of instruction. By giving the kids multiple opportunities to demonstrate their understanding. Doing projects that they want to learn about." Between each sentence she also paused, as if to emphasize the points she made.

The interviewer followed up by asking if there were other things that she did to maximize student learning. The question was restated to allow Sandy to think about the question and perhaps formulate a more in-depth answer. Sandy contemplated the question. She eventually replied that "In the classroom, I try to give the students lots of time to talk about their learning and their thinking. I try to provide a positive atmosphere in which the kids are comfortable to learn. For example, when we did our last unit, which was on genetics, the kids had opportunities to talk to one another and think of questions that were relevant to the lab. The activity was good, as the kids are a generation of CSI [Crime Scene Investigation] watchers and they naturally have questions about the genetics. This lab really grabbed them and allowed them to use their research skills." Sandy continued to talk about the kids and how she wanted them to raise questions, but

later in the interview she shared that she likes having answers for students when they ask questions.

When Sandy had spoken enough about this question (the point at which no new information was added to the conversation), the interviewer asked her about her role as a teacher. Again Sandy was silent for a bit, then answered the question. She started by explaining that she did not want to “be a being of knowledge that gives knowledge to the students. I want to provide them opportunities to ask questions and to model how they can learn on their own. I really want them to be independent learners. I really try to steer clear of lecturing. I always try to set up an activity and let them go at it. If I am successful, I have used real life examples and they are backing their conclusions up with fact.”

Still not clear that an answer was evident, the interviewer restated the question “How does this represent your role as a teacher?” Sandy responded that “I give them an idea or a venue and they get to run this. They get to research it and develop their ideas and show their personality in the assignment. When they do this, they get the chance to learn on their own. Hopefully this knowledge will stick a bit longer. “

After Sandy’s pause, the interviewer quickly asked “What did you do with the kids while they were doing this?”

Sandy responded without a break “I talk to the kids and ask them questions about the assignment. Hopefully, if I ask a question, then they can find the information. You know, they know about the different search engines, but they really don’t know how to determine if it’s good information they are getting. If they need to find information, they can go to the internet, but they need to know if the information is useful. It’s important that I help them understand if the information that they have is good information.”

These two questions, presented in an abbreviated fashion, begin to reveal an orientation that Sandy has towards teaching science. In her first question, Sandy talks about examples that show involvement of the student in the classroom. She is intent on providing good experiences to the students, but has not yet come to develop an interaction between the knowledge students are creating and the knowledge of the students. Her response to the question was coded as *Transitional* (see Table 1).

In her second question, Sandy does not give an easy answer to the question. The answer that she gives reveals that she is intent on giving her students opportunities to learn, which is similar to the response she gave in her first question. Even with additional questions, it is clear that Sandy wants her students to have experiences and that she will help direct these experiences. Her position towards the students and the content result in her being coded as *Instructional* (see Table 1) for this question.

The responses provided by Sandy are typical of most new science teachers. She is building her beliefs about teaching the content, and with more classroom experience these beliefs will certainly change over time. Pivotal in her change will be the type of discussions and experiences she has with colleagues in her first years of teaching.

Looking at a Group of Teachers

We recently completed an analysis of data on a group of 35 first-year secondary science teachers. These teachers were grouped according to the induction program in which they participated: general induction, e-mentoring, science-focused, or alternative

certification programs. Each teacher participated in a pre and post-interview, which was evaluated as described earlier in this paper. While a complete discussion of the research and the complete analysis of the pilot year results are in review (see Luft, Fletcher, Kern, Roehrig, & Brown, in review), it is worth sharing the beliefs data to show the analysis of this data over a year. As our goal in this study was to explore the change in teachers over the year, we first coded the data and created a table showing the averages and standard deviations (see Table 3). When an F-test was conducted to determine significance in change between groups, we found no statistically significant difference between the programs in terms of change in teachers' beliefs ($F(3, 20) = .59, p = .63$).

While the data were not statistically significant for the pilot year, some trends are evident. For instance, we see that teachers tend to have instructional beliefs (around 14). These beliefs tend to shift towards more traditional orientations for those teachers in general programs and in alternative certification programs, while teachers in science-focused and e-mentoring programs (which are also science focused) tend to move towards transitional orientations. Again, these shifts are not significant, but they are evident. In the formal study, we are exploring (among other areas) each belief item, as we have a large enough pool of teachers (120 teachers).

This data is interesting for science teacher educators involved in beliefs research, as it shows that beginning science teachers have beliefs that are aligned with traditional epistemologies. Most science educators would hope that teachers who graduated from their programs would have transitional or instructive beliefs about teaching science. Moreover, the data shows that the beliefs of these teachers did change slightly over the year. These two findings suggest that teachers may have beliefs that are resistant to change and that they may not have been impacted by the pre-service program, or that teachers are forming peripheral beliefs that are slow to change. In the years ahead, we will be exploring these hypotheses, along with others.

Discussion

We consider beliefs to be propositions that individuals think are true. Since these beliefs are based on personal judgment and evaluation, they can be non-evidential; in this sense we concur with Richardson (1996). In terms of science teaching, we consider beliefs to be core and peripheral, as do Brownlee, Boulton-Lewis, and Purdie (2002), and epistemologically oriented, as described by Bendixen, Dunkle, and Schraw (1994). All teachers have personally constructed beliefs about teaching. As teachers engage in their field of instruction, these beliefs expand in their epistemological orientation. Capturing the beliefs of teachers is important to those in science teacher education--ultimately, beliefs reveal how teachers view knowledge and learning, and suggest how they may enact their classroom practice. As peripheral beliefs are forming, it is critical that they be monitored during formative periods such as the first years of teaching or during intensive professional development activities.

While our work has focused on the beliefs of beginning secondary science teachers, we have also worked with pre-service secondary science teachers and experienced secondary science teachers in an effort to understand their beliefs about science teaching. Our studies have revealed, among other findings, that the beliefs of science teachers can change or be modified and that they are likely to do so within certain

parameters. For example, pre-service science teachers who display tendencies towards student-centered activities and instruction can develop more responsive ideologies with specialized support. Correspondingly, they also can move towards more traditional practices in the absence of adequate support. With these types of changes, we concur with Yerrick, Parke and Nugent (1997) that beliefs can be modified, as such beliefs tend to be evolving. In addition, we agree with Fang (1996) that external factors--such as professional development or induction programs--can impact beliefs. Generally, these types of change/modifications represent the tentative nature of beliefs in beginning teachers, supporting the view that beliefs can be newly formed and peripheral (Brownlee, Boulton-Lewis, & Purdie, 2002; Rokeach, 1986).

Like Brownlee, Boulton-Lewis and Purdie (2002) and Wallace and Kang (2004), we found that nascent beliefs are often intertwined. We also found that teachers do not compartmentalize different beliefs. The interplay between beliefs demonstrates that they are nested within each other and are not always discrete entities. For instance, as teachers discuss the learning of students they often make connections to the knowledge of students. These types of connections are important, as they contribute to a more holistic view of teaching. One constraint associated with the connected nature of beliefs, is collecting enough information to analyze the nature of the different beliefs. In realizing this constraint, we make sure that we have adequate information to determine the beliefs of a teacher, and often draw upon answers given in different parts of the interview to understand the orientation of one answer. For example, teachers may talk at length about their role as a teacher, but later in the interview they may give an example that highlights this position. To negotiate the nestedness of beliefs, one researcher is responsible for coding all of the pre- or post-interview questions of a science teacher, as opposed to just coding the first, second, or third question.

In addition to these findings, we have reported on other aspects of beliefs over the years. These findings can be found in several of our papers and include the following (see; Luft, 2001; Luft, Fletcher, Fortney, 2005; Luft, Lee, Fletcher, & Roehrig, in press; Luft, Roehrig, & Patterson, 2003; Roehrig & Luft, 2004a; Roehrig & Luft, 2004b; Roehrig & Luft, 2006):

- Science teachers with transitional beliefs are more likely to move towards traditional or reform-based dispositions;
- Beginning secondary science teachers have primarily instructive and transitional beliefs;
- Beginning secondary science teachers' beliefs are more likely to change than those of their experienced peers;
- The beliefs of beginning secondary science teachers as depicted in this interview process (traditional, instructive, transitional, responsive, reform-based), tend to correspond with traditional (traditional or instructive), guided (transitional) or inquiry-based (responsive or reform-based) practices;
- The beliefs of beginning secondary science teachers can be impacted by subject-specific induction programs;
- Aspects of teacher education programs can impact the beliefs of science teachers differently, with some courses fostering more traditional or reform-based beliefs.

As we explored the beliefs of teachers, we elected to engage in an interview process. This process does give us access to the beliefs of teachers, which are the deep-seated views that direct practice. While some have argued that beliefs data without observational data or multiple data sources is problematic (Pajares, 1992; Richardson, 1996), we feel otherwise. In fact, from our experience, interviews can provide access to the thinking of teachers. Moreover, the interview process allows the teacher to reveal the complexity of the belief system. Interviews, in our experience, do transcend the shortcomings of written responses that have been described by other researchers (Fang, 1996; Munby, 1982). Collecting observational data may be important in order to determine the translation of beliefs into practice, but conducting both to understand one event may confound our understanding of the nature of the beliefs of teachers. In our experience, detangling beliefs from practice is important, and interviews with teachers about practice and experiences do reveal the beliefs that teachers hold.

Conclusion

Understanding the beliefs of teachers is critical if those of us in science teacher education are going to develop programs that have a lasting impact on our teachers. As we begin to understand how the beliefs of science teachers form, we will be able to develop pre-service and professional development programs that are conducive to the optimal development of science teachers. Ultimately, this could result in a different configuration of course work and activities in a pre-service program or different processes that can be drawn upon during the professional development experience.

As we embark on beliefs research, we should be looking for new ways to reveal the beliefs of teachers. Our work with interviews suggests one viable option to the use of traditional paper and pencil tests to measure beliefs. Moreover, our work in this area suggests a method for looking at the emerging beliefs of the teacher. Along with the development of techniques to monitor the beliefs of teachers, science educators should also follow the beliefs of teachers throughout their development, as well as try to understand how the beliefs of teachers are connected to practice. Moreover, as beliefs are followed, consideration should be given to the types of experiences that impact the beliefs of teachers. In the coming years, this new information about teachers' beliefs will hold great interest for the science education research community.

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Table 1. TBI Category Description

Category	Example	View of Science
Traditional: Focus on information, transmission, structure, or sources.	I am an all knowing sage. My role is to deliver information.	Science as rule or fact.
Instructive: Focus on providing experiences, teacher-focus, or teacher decision.	I want to maintain a student focus to minimize disruptions. I want to provide students with experiences in laboratory science (no elaboration).	
Transitional: Focus on teacher/student relationships, subjective decisions, or affective response.	I want a good rapport with my students, so I do what they like in science. I am responsible to guide students in their development of understanding and process skills.	Science as consistent, connected and objective.
Responsive: Focus on collaboration, feedback, or knowledge development.	I want to set up my classroom so that students can take charge of their own learning.	Science as a dynamic structure in a social and cultural context.
Reform-based: Focus on mediating student knowledge or interactions.	My role is to provide students with experiences in science which allows me to understand their knowledge and how they are making sense of science. My instruction needs to be modified accordingly so that students understand key concepts in science.	

Table 2. Beliefs Profile of Teacher A.

	Traditional	Instructive	Transitional	Responsive	Reform-based
Int. 1	****	**	*		
Int. 2	***	***	*		
Int. 3		***	****		
Int. 4		**	***	**	

Table 3. Beliefs of Teachers in Different Induction Programs

	General (10)	e-Mentoring (7)	Science specific (8)	Mentoring and certification (10)
Pre-beliefs	15.20 (3.96)	14.33 (1.63)	15.20 (2.68)	14.75 (4.40)
Post-beliefs	14.40 (2.88)	15.67 (2.42)	16.20 (4.21)	14.38 (2.13)

Figure 1. Beliefs Questions













